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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
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| 10/768,724 | 01/30/2004 | Wei liu | AMAT/8736/DSM/BCVD/JW | 5121 |
| 44257 | 7590 | 10/17/2005 | EXAMINER | |
| PATTERSON & SHERIDAN, LLP 3040 POST OAK BOULEVARD, SUITE 1500 HOUSTON, TX 77056 | | | CHEN, ERIC BRICE | |
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1765

DATE MAILED: 10/17/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

16

| | | | |
|------------------------------|-----------------|--------------|--|
| Office Action Summary | Application No. | Applicant(s) | |
| | 10/768,724 | LIU ET AL. | |
| | Examiner | Art Unit | |
| | Eric B. Chen | 1765 | |

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 1/30/04.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-23 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-23 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
 Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
 Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|---|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date <u>5/04; 7/05; 8/05</u> | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Priority

1. Applicant is advised of possible benefits under 35 U.S.C. 119(a)-(d), wherein an application for patent filed in the United States may be entitled to the benefit of the filing date of a prior application filed in a foreign country.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

3. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

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4. Claims 1, 3, and 4 are rejected under 35 U.S.C. 103(a) as being unpatentable over Grill et al. (U.S. Patent No. 6,140,226) in view of Bosner et al (U.S. Patent No. 6,764,949).

5. As to claim 1, Grill discloses method of etching a substrate, comprising: depositing a mask layer (78) on the substrate (8/10/12) (column 9, lines 24-28; Figure 7A); defining a first pattern in the mask layer (78) (column 9, lines 33-35; Figure 7C); depositing a layer of photoresist (82) on the mask layer (78) (column 9, lines 40-43; Figures 7B-7C); patterning the photoresist (82) (column 9, lines 40-43; Figure 7D); transferring the pattern in the photoresist (82) through the mask layer (78) to form a second pattern in the mask layer (78) (column 9, lines 45-50; Figure 7E); and transferring the first and second patterns in the mask layer through the substrate (8/10/12) (column 9, lines 58-67; column 10, line 1; Figures 7G-7I).

6. Grill does not expressly disclose that mask layer (78) is amorphous carbon. However, in a separate embodiment, Grill discloses that one suitable hard mask material is a carbon-based dielectric (column 8, lines 30-35). Moreover, Bonser teaches that the use amorphous carbon hardmasks are beneficial because they are easily patterned, have a high selectivity relative to other hardmask materials such as silicon oxide, silicon nitride, and silicon oxynitride (column 1, lines 19-25). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to form the mask layer with amorphous carbon. One who is skilled in the art would be motivated to use a material that is easily patterned and has a high selectivity

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relative to other hardmask materials such as silicon oxide, silicon nitride, and silicon oxynitride.

7. As to claim 3, Grill discloses that the substrate (8/10/12) comprises a material selected from the group consisting of silicon, polysilicon, an oxide, a nitride, tungsten, tungsten silicide, aluminum, silicon oxycarbide, and combinations thereof (column 4, lines 5-10).

8. As to claim 4, Grill discloses depositing a layer (76) selected from the group consisting of amorphous silicon, silicon nitride (column 9, lines 29-30), silicon oxynitride, silicon oxide, doped silicon oxide, silicon oxycarbide, carbides, silicon carbide, titanium, and titanium nitride on the substrate before the depositing the amorphous carbon layer. Although Grill does not expressly disclose layer (76) as an anti-reflective coating, silicon nitride inherently behaves as an anti-reflective coating. See Wolf, *Silicon Processing for the VLSI Era*, Vol. 4, Lattice Press (2002), page 249.

Claim Rejections - 35 USC § 103

9. Claims 2, 5, and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Grill, in view of Bosner, in further view Latchford et al. (U.S. Patent Appl. Pub. No. 2002/0001778).

10. As to claim 2, Grill does not expressly disclose that the amorphous carbon layer is deposited by vapor deposition from a gas mixture comprising one or more hydrocarbons having the general formula C_xH_y , wherein x has a range of 2 to 4 and y has a range to 2 to 10. However, Latchford discloses a method of forming an

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amorphous carbon layer for hardmasks (paragraphs 0014-0016), including depositing by vapor deposition from a gas mixture comprising one or more hydrocarbons having the general formula C_xH_y , wherein x has a range of 2 to 4 and y has a range to 2 to 10 (paragraph 0039). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to deposit, by vapor deposition from a gas mixture comprising one or more hydrocarbons having the general formula C_xH_y , wherein x has a range of 2 to 4 and y has a range to 2 to 10. One who is skilled in the art would be motivated to use a method that has been successfully established in forming amorphous carbon hardmasks.

11. As to claim 5, Grill does not expressly disclose that the amorphous carbon layer is deposited at a power of between about 1 W/in² and about 100 W/in². However, Latchford discloses a method of forming an amorphous carbon layer for hardmasks (paragraphs 0014-0016), including depositing at a power of between about 1 W/in² and about 100 W/in². Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to deposit at a power of between about 1 W/in² and about 100 W/in². One who is skilled in the art would be motivated to use a method that has been successfully established in forming amorphous carbon hardmasks.

12. As to claim 6, Grill does not expressly disclose removing the amorphous carbon layer from the substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate. However, Latchford discloses removal of the removing the amorphous carbon layer from the substrate (paragraphs 0052, 0081). Latchford teaches that removal of the amorphous carbon layer may be necessary prior

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the forming of overlying layers when continuing the manufacturing process (paragraph 0081). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to remove the amorphous carbon layer from the substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate. One who is skilled in the art would be motivated to remove any undesirable material layers after processing has been completed.

Claim Rejections - 35 USC § 103

13. Claims 7, 9-10, 12-13, 15-18, 20, and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Grill, in view of Bosner, in further view of Wolf, *Silicon Processing for the VLSI Era*, Vol. 4, Lattice Press (2002).

14. As to claim 7, Grill discloses method of etching a substrate, comprising: depositing a mask layer (78) on the substrate (8/10/12) (column 9, lines 24-28; Figure 7A); defining a first pattern in the mask layer (78) (column 9, lines 33-35; Figure 7C); depositing a layer of photoresist (82) on the mask layer (78) (column 9, lines 40-43; Figures 7B-7C); patterning the photoresist (82) (column 9, lines 40-43; Figure 7D); transferring the pattern in the photoresist (82) through the mask layer (78) to form a second pattern in the mask layer (78) (column 9, lines 45-50; Figure 7E); and transferring the first and second patterns in the mask layer through the substrate (8/10/12) (column 9, lines 58-67; column 10, line 1; Figures 7G-7I).

15. Grill does not expressly disclose that mask layer (78) is amorphous carbon. However, in a separate embodiment, Grill discloses that one suitable hard mask

material is a carbon-based dielectric (column 8, lines 30-35). Moreover, Bonser teaches that the use amorphous carbon hardmasks are beneficial because they are easily patterned, have a high selectivity relative to other hardmask materials such as silicon oxide, silicon nitride, and silicon oxynitride (column 1, lines 19-25). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to form the mask layer with amorphous carbon. One who is skilled in the art would be motivated to use a material that is easily patterned and has a high selectivity relative to other hardmask materials such as silicon oxide, silicon nitride, and silicon oxynitride.

16. Grill does not expressly disclose depositing a non-carbon based layer on the amorphous carbon layer. However, photoresist (80) is formed over mask (76) (column 9, lines 31-33; Figure 7B). Wolf teaches that anti-reflective coatings are often deposited between the substrate and photoresist to minimize standing waves and reflective notching from substrate reflections, and as a result, maintaining control over critical dimensions (pages 244-45). Moreover, Wolf teaches that inorganic materials may also be used as anti-reflective coatings, which can be deposited to conformally coat underlying topography (page 249-250). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to deposit a non-carbon based layer on the amorphous carbon layer. Moreover, it would have been obvious to one of ordinary skill in the art to modify Grill's process to account for an additional non-carbon based layer, including defining a pattern in the non-carbon based layer; and transfer the pattern in the photoresist through the non-carbon based layer. One who is

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skilled in the art would be motivated to form a conformal anti-reflective coating to maintain control over critical dimensions.

17. As to claim 9, Grill discloses that the substrate (8/10/12) comprises a material selected from the group consisting of silicon, polysilicon, an oxide, a nitride, tungsten, tungsten silicide, aluminum, silicon oxycarbide, and combinations thereof (column 4, lines 5-10).

18. As to claim 10, Grill discloses depositing a layer (76) selected from the group consisting of amorphous silicon, silicon nitride (column 9, lines 29-30), silicon oxynitride, silicon oxide, doped silicon oxide, silicon oxycarbide, carbides, silicon carbide, titanium, and titanium nitride on the substrate before the depositing the amorphous carbon layer. Although Grill does not expressly disclose layer (76) as an anti-reflective coating, silicon nitride inherently behaves as an anti-reflective coating. See Wolf, *Silicon Processing for the VLSI Era*, Vol. 4, Lattice Press (2002), page 249.

19. As to claim 12, Wolf discloses that the non-carbon based layer is selected from the group consisting of amorphous silicon, silicon nitride (page 249), silicon oxynitride (page 249), silicon oxide, doped silicon oxide, silicon oxycarbide, carbides, silicon carbide, titanium, and titanium nitride (page 250).

20. As to claim 13, Wolf discloses that the non-carbon based layer has a thickness of between about 50 Å and about 500 Å (page 249).

21. As to claim 15, Grill discloses method of etching a substrate, comprising: depositing a mask layer (78) on the substrate (8/10/12) (column 9, lines 24-28; Figure 7A); defining a first pattern in the mask layer (78) (column 9, lines 33-35; Figure 7C);

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depositing a layer of photoresist (82) on the mask layer (78) (column 9, lines 40-43; Figures 7B-7C); patterning the photoresist (82) (column 9, lines 40-43; Figure 7D); transferring the pattern in the photoresist (82) through the mask layer (78) to form a second pattern in the mask layer (78) (column 9, lines 45-50; Figure 7E); and transferring the first and second patterns in the mask layer through the substrate (8/10/12) (column 9, lines 58-67; column 10, line 1; Figures 7G-7I).

22. Grill does not expressly disclose that mask layer (78) is amorphous carbon. However, in a separate embodiment, Grill discloses that one suitable hard mask material is a carbon-based dielectric (column 8, lines 30-35). Moreover, Bonser teaches that the use amorphous carbon hardmasks are beneficial because they are easily patterned, have a high selectivity relative to other hardmask materials such as silicon oxide, silicon nitride, and silicon oxynitride (column 1, lines 19-25). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to form the mask layer with amorphous carbon. One who is skilled in the art would be motivated to use a material that is easily patterned and has a high selectivity relative to other hardmask materials such as silicon oxide, silicon nitride, and silicon oxynitride.

23. Grill does not expressly disclose depositing a non-carbon based layer on the amorphous carbon layer. However, photoresist (80) is formed over mask (76) (column 9, lines 31-33; Figure 7B). Wolf teaches that anti-reflective coatings are often deposited between the substrate and photoresist to minimize standing waves and reflective notching from substrate reflections, and as a result, maintaining control over critical

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dimensions (pages 244-45). Moreover, Wolf teaches that inorganic materials may also be used as anti-reflective coatings, which can be deposited to conformally coat underlying topography (page 249-250). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to deposit a non-carbon based layer on the amorphous carbon layer. Moreover, it would have been obvious to one of ordinary skill in the art to modify Grill's process to account for an additional non-carbon based layer, including defining a pattern in the non-carbon based layer; and transfer the pattern in the photoresist through the non-carbon based layer. One who is skilled in the art would be motivated to form a conformal anti-reflective coating to maintain control over critical dimensions.

24. Grill does not expressly disclose depositing a second non-carbon based layer on the amorphous carbon layer; depositing a layer of photoresist on the second non-carbon based layer; and transferring the pattern in the photoresist through the second non-carbon based layer. However, Grill discloses that substrate (8/10/12) may be formed of silicon oxynitride (SiON) (column 4, lines 5-10). Wolf also teaches that SiON is a common anti-reflective material (page 249) and that SiON interactions with the photoresist could produce adverse reactions (page 250). To prevent such reactions, a thin oxide barrier is formed before depositing the photoresist (page 250). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention to depositing a second non-carbon based layer on the amorphous carbon layer. Moreover, one who is skilled in the art would be motivated to modify Grill's process to account for a second non-carbon based layer, including depositing a layer of photoresist

on the second non-carbon based layer; and transferring the pattern in the photoresist through the second non-carbon based layer. One who is skilled in the art would be motivated to prevent adverse reactions between the silicon oxynitride and photoresist by forming an inert oxide barrier between the two materials.

25. As to claim 16, Wolf discloses that the non-carbon based layer is selected from the group consisting of amorphous silicon, silicon nitride (page 249), silicon oxynitride (page 249), silicon oxide, doped silicon oxide, silicon oxycarbide, carbides, silicon carbide, titanium, and titanium nitride (page 250).

26. As to claim 17, Wolf discloses that the non-carbon based layer has a thickness of between about 50 Å and about 500 Å (page 249).

27. As to claim 18, Wolf discloses that the second non-carbon based layer is selected from the group consisting of amorphous silicon, silicon nitride, silicon oxynitride, silicon oxide (page 250), doped silicon oxide, silicon oxycarbide, carbides, silicon carbide, titanium, and titanium nitride.

28. As to claim 20, Grill discloses that the substrate (8/10/12) comprises a material selected from the group consisting of silicon, polysilicon, an oxide, a nitride, tungsten, tungsten silicide, aluminum, silicon oxycarbide, and combinations thereof (column 4, lines 5-10).

29. As to claim 21, Grill discloses depositing a layer (76) selected from the group consisting of amorphous silicon, silicon nitride (column 9, lines 29-30), silicon oxynitride, silicon oxide, doped silicon oxide, silicon oxycarbide, carbides, silicon carbide, titanium, and titanium nitride on the substrate before the depositing the amorphous carbon layer.

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Although Grill does not expressly disclose layer (76) as an anti-reflective coating, silicon nitride inherently behaves as an anti-reflective coating. See Wolf, *Silicon Processing for the VLSI Era*, Vol. 4, Lattice Press (2002), page 249.

Claim Rejections - 35 USC § 103

30. Claims 8, 11, 14, 19, 22, and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Grill, in view of Bosner, in view of Wolf, in further view Latchford.

31. As to claims 8 and 19, Grill does not expressly disclose that the amorphous carbon layer is deposited by vapor deposition from a gas mixture comprising one or more hydrocarbons having the general formula C_xH_y , wherein x has a range of 2 to 4 and y has a range to 2 to 10. However, Latchford discloses a method of forming an amorphous carbon layer for hardmasks (paragraphs 0014-0016), including depositing by vapor deposition from a gas mixture comprising one or more hydrocarbons having the general formula C_xH_y , wherein x has a range of 2 to 4 and y has a range to 2 to 10 (paragraph 0039). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to deposit, by vapor deposition from a gas mixture comprising one or more hydrocarbons having the general formula C_xH_y , wherein x has a range of 2 to 4 and y has a range to 2 to 10. One who is skilled in the art would be motivated to use a method that has been successfully established in forming amorphous carbon hardmasks.

32. As to claim 11 and 22, Grill does not expressly disclose that the amorphous carbon layer is deposited at a power of between about 1 W/in² and about 100 W/in².

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However, Latchford discloses a method of forming an amorphous carbon layer for hardmasks (paragraphs 0014-0016), including depositing at a power of between about 1 W/in² and about 100 W/in². Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to deposit at a power of between about 1 W/in² and about 100 W/in². One who is skilled in the art would be motivated to use a method that has been successfully established in forming amorphous carbon hardmasks.

33. As to claim 14, Grill does not expressly disclose removing the amorphous carbon layer and the non-carbon based layer from the substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate.

However, Latchford discloses removal of the removing the amorphous carbon layer from the substrate (paragraphs 0052, 0081). Latchford teaches that removal of the amorphous carbon layer may be necessary prior the forming of overlying layers when continuing the manufacturing process (paragraph 0081). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to remove the amorphous carbon layer from the substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate. One who is skilled in the art would be motivated to remove any undesirable material layers after processing has been completed.

34. Wolf further teaches that the use of low-k dielectrics can significantly improve circuit performance characteristics (page 639). Moreover, Wolf teaches that any dielectric layers with a higher k value increases the overall k-value of the dielectric stack

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(pages 679-680). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to the non-carbon based layer from the substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate. One who is skilled in the art would be motivated to reduce the overall k-value of the dielectric stack to improve circuit performance characteristics.

35. As to claim 23, Grill does not expressly disclose removing the amorphous carbon layer and the second non-carbon based layer from the substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate. However, Latchford discloses removal of the removing the amorphous carbon layer from the substrate (paragraphs 0052, 0081). Latchford teaches that removal of the amorphous carbon layer may be necessary prior the forming of overlying layers when continuing the manufacturing process (paragraph 0081). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to remove the amorphous carbon layer from the substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate. One who is skilled in the art would be motivated to remove any undesirable material layers after processing has been completed.

36. Wolf further teaches that the use of low-k dielectrics can significantly improve circuit performance characteristics (page 639). Moreover, Wolf teaches that any dielectric layers with a higher k value increases the overall k-value of the dielectric stack (pages 679-680). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to the second non-carbon based layer from the

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substrate after the first and second patterns in the amorphous carbon layer are transferred through the substrate. One who is skilled in the art would be motivated to reduce the overall k-value of the dielectric stack to improve circuit performance characteristics.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Eric B. Chen whose telephone number is (571) 272-2947. The examiner can normally be reached on Monday through Friday, 8AM to 4:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine G. Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

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EBC

Oct. 7, 2005

EBC

NADINE G. NORTON
SUPERVISORY PATENT EXAMINER

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